560.1 DESCRIPTION

This work consists of furnishing and installing precast and prestressed concrete items.

560.2 MATERIALS

A. Concrete:

1. **Fine Aggregate**: Section 800.

2. **Coarse Aggregate**: Section 820. Coarse aggregate shall meet the gradation requirements of Size No. 1 or Size No. 1A. The aggregate size shall be consistent throughout the entire structure. One source shall be used to produce each aggregate size.

3. **Water**: Section 790.

4. **Admixtures:** Section 751 and 752.

5. **Fly Ash:** Section 753.

B. Pretensioning Reinforcement: Section 1010.

C. Reinforcing Steel: Section 1010.

D. Drainage Fabric: Section 831.1 – Type A.

560.3 CONSTRUCTION REQUIREMENTS

A. General Requirements: The Contractor shall satisfy the following for all precast/prestressed concrete items.

1. **Fabrication:** Fabricators shall be on the approved fabricators list prior to fabricating precast and prestressed concrete items.

2. **Concrete Mix Requirements:** The Contractor shall submit a concrete job mix design for approval ten working days prior to fabrication. The mix design shall include all aggregate sources, admixtures proposed for use and shall contain a minimum of 58 percent coarse aggregate by weight. When a plant has been in operation and satisfactorily producing material, the Contractor will not be required to submit a concrete mix design, unless changes have been made to the pre-approved mix design or the material used in the mix design.

   The concrete shall attain a 28 day compressive strength equal to or greater than the minimum compressive strength specified.

   The water/cementitious material ratio shall not exceed that specified in the concrete mix design.

The entrained air content shall be 6 percent plus or minus 1.5 percent.

Concrete without high range water reducing admixtures (HRWRA) shall have a maximum slump of five inches (125 mm).

When HRWRA are used, the slump at the time of placement shall be from four inches (100 mm) to eight inches (200 mm).

The HRWRA shall be compatible with the concrete mix. The HRWRA shall not be used in amounts that cause segregation or rapid slump loss that would hinder concrete placement.

Equipment and methods used for batching, mixing, and transporting of concrete shall be approved by the Engineer.

3. **Shop Drawings:** Fifteen days prior to fabrication, the Contractor shall furnish shop drawings for Department review. The shop drawings shall consist of fabrication details including reinforcing steel and spacer placement and configurations, total quantities for the complete structure, and all information necessary for fabrication and erection.

   Shop drawings for prestressed concrete items shall also include the method and sequence of stressing.

4. **Forms:** The forms shall be designed to withstand the fluid pressure of the concrete and the added forces due to vibration and impact without distortion. The forms shall be mortar tight and free from warp.

   The form area in contact with the concrete shall be treated with an approved form oil or wax before the form is set in position. The forms shall be thoroughly cleaned of all other substances.

5. **Concrete Cure:** The concrete shall be cured by low pressure steam, radiant heat, or as specified in Section 460.3 N. When curing in accordance with Section 460.3 N., the concrete temperature requirements of Section 460.3 O. shall apply.

   Low pressure steam or radiant heat curing shall be done under an enclosure to contain the live steam or the heat and prevent heat and moisture loss. The concrete shall be allowed to attain initial set before application of the steam or heat. The initial application of the steam or heat shall be three hours after the final placement of concrete to allow the initial set to occur. When retarders are used, the waiting period before application of the steam or radiant heat shall be five hours. When the time of initial set is determined by ASTM C 403, the time limits described above may be waived.

   During the waiting period, the minimum temperature within the curing chamber shall not be less than 50° F (10° C) and live steam or radiant heat may be used to maintain the curing chamber between 50° F (10° C) and 80° F (27° C). During the waiting period the concrete shall be kept moist.

Application of live steam shall not be directed on the concrete forms causing localized high temperatures. Radiant heat may be applied by pipes circulating steam, hot oil, hot water, or by electric heating elements. Moisture loss shall be minimized by covering exposed concrete surfaces with a plastic sheeting or by applying an approved liquid membrane curing compound to exposed concrete surfaces. The top surface of concrete members for use in composite construction shall be free of membrane curing compound residue unless suitable mechanical means for full bond development are provided.

During the initial application of live steam or radiant heat, the concrete temperature shall increase at an average rate not exceeding 40° F (22° C) per hour until the curing temperature is reached. The maximum concrete temperature shall not exceed 160° F (71° C). The maximum temperature shall be held until the concrete has reached the desired strength. After discontinuing the steam or radiant heat application, the temperature of the concrete shall decrease at a rate not to exceed 40° F (22° C) per hour until the concrete temperature is within 20° F (11° C) of the ambient air temperature. The Contractor will not be required to monitor this cool down temperature when the ambient air temperature is 20° F (11° C) or above.

The test cylinders shall be cured with the unit, or in a similar manner (similar curing method and concrete curing temperature, as approved by the Concrete Engineer) as the unit, until minimum compressive strength has been obtained

6. **Surface Finish and Patching:** If a precast or prestressed item shows stone pockets, honeycomb, delamination or other defects which may be detrimental to the structural capacity of the item, it will be subject to rejection at the discretion of the Engineer. Minor surface irregularities or cavities, which do not impair the service of the item, and which are satisfactorily repaired will not constitute cause for rejection. Repairs shall not be made until the Engineer has inspected the extent of the irregularities and has determined whether the item can be satisfactorily repaired. If the item is deemed to be repairable, the repair method and procedures shall be agreed upon by the Department and fabricator prior to the work commencing.

   Depressions resulting from the removal of metal ties or other causes shall be carefully pointed with a mortar of sand and cement in the proportions, which are similar to the specific class of concrete in the unit. A sack rub finish is required on prestressed beams except for the bottom of the bottom flange and the top of the top flange. A sack rub finish is also required on sloped surfaces of box culvert end sections.

B. Precast Box Culverts: The following shall apply to box culverts:

1. **Design:** Precast concrete box culverts shall conform to AASHTO M 259 or M 273. Configurations in variance with those provided by AASHTO will be accepted provided the AASHTO materials, design, fabrication specification and the requirements of this Section are complied with.

   Box culvert end sections (inlet or outlet) materials, design, and fabrication shall conform to AASHTO Standard Specifications for Highway Bridges and Materials Specifications.

Precast box culverts shall be designed to specified load conditions. The Design Engineer of the structure must be registered in the State of South Dakota. The design shall conform to the AASHTO design requirements for the depth of fill, including surfacing, etc., as well as live load or specified loading. The specified live load shall apply to all barrel sections.

Minimum reinforcing steel clear cover shall be 1 inch (25mm) for all member faces. The exception to this is that box culverts covered by a fill of less than 2 feet (0.6 m) shall have a minimum reinforcing steel clear cover of 2 inches (50 mm) in the top of the top slab.

The Contractor shall furnish a checked design with the shop drawings. A checked design includes the design calculations, and check design calculations performed by an independent Engineer.

A checked design for barrel sections will not be required to be submitted if the proposed fabrication dimensions and reinforcement conform to AASHTO M 259M or M 273M. A checked design for the end sections and special sections will be required.

2. Fabrication: The Contractor shall notify the Engineer seven days prior to fabrication.

The minimum length of precast section shall be four feet. (1200 mm)

Welding of reinforcing steel will not be permitted.

Joint ties shall be provided on all sections.

Steel wire bar supports shall be used to maintain proper reinforcement location and concrete cover. Cutting of reinforcement and bending to the form surface, for support, will not be permitted. Steel wire bar supports, in contact with the casting forms, shall be stainless steel, hot dipped galvanized, or plastic tipped extending at least ½ inch (13 mm) from the form surface.

The surface temperature of forms and reinforcing steel (that come in contact with the concrete being placed) shall be raised to a temperature above freezing prior to concrete placement. All deleterious material shall be removed from the forms prior to concrete placement.

The dry casting method of fabrication for precast concrete box culverts will not be allowed.

The precast units shall have sufficient strength to prevent damage to the units during removal of the forms and yarding. Precast units shall have a minimum concrete compressive strength of 800 psi (5.5 MPa) prior to form removal. Precast units shall have a minimum concrete compressive strength of 3000 psi (21 MPa) prior to yarding. The Engineer may approve a different minimum concrete strength for form removal and yarding, based upon fabricator demonstrated results or as shown on design details submitted and approved with the shop plans.

The fabricator shall make a minimum of one group of test cylinders for each class of concrete for each days production, not to exceed 150 cubic yards (125 cubic meters) per group of cylinders.

At a minimum, a group of test cylinders shall consist of the following:

a. Two test cylinders are required for the 28 day compression test.

b. Two additional cylinders will be required for determining concrete strength, when the Contractor desires to make delivery and obtain acceptance by the Department prior to the 28 day compression test.

Acceptance of the precast units shall be in accordance with Section 460.3.B.The precast units will be accepted when the minimum design concrete compressive strength requirements have been met. Accepted precast units represented by that test group of cylinders may be delivered to the project and will not require the 28 day cylinder test.

3. Installation: Box culvert installation shall conform to the approved shop drawings and the following:

a. Foundation: Foundation preparation shall be in accordance with Sections 420, 421, and 450. The foundation shall be shaped to provide a satisfactory template section and density.

b. Transverse Joints: The floor joint between adjacent sections shall be sealed with a preformed mastic along the floor to the top of the haunches. Fabric shall be placed along the top and walls, to provide a minimum of 2 ½ feet (750 mm) of fabric centered on the joint. Transverse joints in the fabric shall be overlapped at least two feet (600 mm). Sufficient adhesive shall be required along the edge of the fabric to hold it in place while backfilling. The lift holes shall be plugged with an approved non-shrink grout or as shown on the approved shop drawings.

The maximum allowable gap at any point between adjacent sections of box culvert shall be 1” (25 mm).

c. Joint Ties: Each section shall be tied to adjacent sections with joint ties as shown on the approved shop drawings.

d. Backfilling: Backfilling shall conform to Section 450. Hand compaction methods may be required for satisfactory compaction under and adjacent to corners with radius and between culverts on multiple installations.

C. Prestressed Concrete: The following shall apply to all prestressed concrete products:

1. General: The Contractor shall notify the Engineer at least seven days prior to fabrication to permit inspection of the forms and reinforcement by Department personnel.

The Contractor shall have a PCI Level II Certified technician, skilled in the prestressing method used, available to provide assistance and instruction in the use of the prestressing equipment and installation of materials.

Prestressing shall be by the pretensioning method. All common or similar elements shall be prestressed using the same method.

The Contractor shall prevent damage to prestressing steel that weakens the prestressing steel or may cause failure under stress. Nicking, kinking, or twisting of the prestressing steel will not be permitted. Sparks or pieces of molten metal from welding or burning equipment shall not contact any prestressing steel. The use of prestressing steel as a ground for welding equipment will not be permitted. The cutting of surplus tendons by burning will be permitted providing the burning is done rapidly and neatly. The term "prestressing steel" shall be that portion of the prestressing tendons, which will be incorporated in the work.

2. **Forms:** Forms shall comply with Section 423.3 and the following:

   Joints in sectional forms shall have a tight fit without excessive offset.

   Forms shall be set on a rigid foundation and the soffit form shall be a plane surface at right angles to the vertical axis of the beam.

   The beams shall be accurately cast to the dimensions shown in the plans or in the shop drawings. Requests for minor shape changes to accommodate the available forms shall be accompanied by design calculations.

3. **Steel Units:** Reinforcement and tendons shall be placed in the position specified and securely held during the placing and setting of the concrete. The distances between the forms and steel shall be maintained by metal bar chairs, spacers, hangers, and precast mortar or concrete blocks of approved shape and dimensions. Metal devices in contact with the forms shall be galvanized. Distances between layers of units shall be maintained by metal spacers, precast mortar, or concrete blocks. Welding of reinforcement or tendons will not be allowed.

   Loose rust, dirt, oil, or other foreign substances shall be removed from the prestressing tendons before the side forms are erected.

   The hold down devices for deflected strands shall provide for the removal of the device for a distance of one inch (25 mm) or more from the exposed face of the concrete and the resulting hole patched with mortar. As an alternative, the device shall rest on the bottom form and remain in place after concrete placement. When the hold down devices are to remain in place, the portion of the devices in contact with the forms shall be galvanized for a minimum distance of one inch (25 mm).

4. **Tensioning:**

   a. **Equipment:** Equipment, tools, and machinery used in the work shall be adequate for the purpose for which they are to be used and shall be appropriately maintained.

In all methods of tensioning, the stress induced in the prestressing elements shall be measured both by jacking gages and by elongation of the elements. The results shall check as specified in paragraph two below. Means shall be provided for measuring the elongation of reinforcement to the nearest 1/16 inch (whole millimeter). Stressing devices, whether hydraulic jacks or screw jacks, shall be equipped with accurate calibrated pressure gages, rings, or other devices applicable to the type of jack being used. Jacks, gages, and pumps shall be calibrated as a unit by a competent laboratory under conditions similar to operating conditions. A dated, certified calibration curve shall be furnished for each combination used. Calibration of jacks, gages, and load cells shall be repeated annually or after an overhaul. Recalibration will be required for all equipment that produces erratic results during tensioning operations.

The sensitivity and accuracy of the gages shall be such that at final elongation the total load on the jack(s) can be accurately determined within a tolerance of five percent of the total indicated stress at that time.

b. General Procedures: The tensioning procedure shall be conducted so the indicated stress on the tendons based on gage pressures and the indicated stress based on the corresponding elongation of the tendons may be measured and compared at any time. When the two indicated stresses, corrected for friction loss, differ by five percent or less, the tendons shall be stressed so the lower of the two indicated stresses is equal to the required tension in the tendon. If the difference exceeds five percent, tensioning operations shall cease until the source of the discrepancy has been determined and corrected. Alternate stressing procedures shall be approved by the Engineer prior to fabrication.

Tendons shall be tensioned to produce the forces shown in the plans, or on the approved working drawings with appropriate allowances for all losses. Losses to be provided for shall be as specified in Section 9.16 of Division I, Design, of the AASHTO Standard Specifications for Highway Bridges. The maximum temporary stress (jacking stress) and the stress in the steel before loss due to creep and shrinkage shall not exceed the values allowed in Section 9.15 of Division I, Design, of the AASHTO Specifications.

Each strand shall be given an initial tension of such magnitude and shall be supported at such intervals that the strand is straightened and the slack removed before jacking is started. Strands tensioned as a group shall have the same initial tension and all strands in the group shall be from the same manufacturer.

The tensioning of deflected strands shall be done so that the final tension in all parts of the strand is uniform and means shall be provided to reduce frictional forces at the bend points to a minimum. Hold down devices shall contain rollers to aid in minimizing the effects of friction.

Tension elongation measurements shall be corrected for losses as determined in the field due to slippage of wedges or anchorages, and friction, to obtain the required prestress force in the strands after anchorage's are set.

Appreciable changes in elongation of the strands due to a temperature differential in the strands between the tensioning and time of concrete placement shall be considered in the final elongation measurements to obtain the required prestress force at the time of casting. The change in elongation due to temperature shall be based on 1/8 inch per 100 feet (3 mm per 30 meters) of strand length for each 15° F (10.0° C) variation in temperature. Temperature corrections shall be performed as per PCI standards and details of temperature corrections shall be submitted prior to fabrication.

5. **Placement of Concrete:** The surface temperature of the forms and reinforcing steel, which come into contact with the concrete being placed shall be raised to a temperature above freezing prior to concrete placement. All deleterious material shall be removed from the forms prior to concrete placement.

   Beams shall be cast in an upright position and the concrete shall be placed in continuous lifts not exceeding one half the depth of the beam. A continuous flow of concrete from end to end of the beam may be permitted provided segregation of the concrete is not taking place. Cold joints or initial set between lifts will not be allowed.

   The rate of placement shall be maintained at a minimum rate such that no cold joints exist in the beam.

   The concrete in each beam shall be vibrated internally, externally, or both to produce uniformly dense concrete and to avoid displacement of enclosures or steel units.

   The top surface of the beam shall be float finished to seal the surface and depress the coarse aggregate. After finishing and prior to initial set, the top surface shall be given a transverse grooving. The grooves shall be approximately ¼ inch (6 mm) deep by ¼ inch (6 mm) wide at one inch (25 mm) spaces. The top surface of the outside edges of the top flange shall be finished with a concrete edging tool for the full length of the beam. The edging tool shall be of sufficient size to produce a smooth finish for approximately the outside 3 inches (75 mm) of flange top width. In addition, a smooth spot shall be left at the span tenth points.

6. **Form Removal:** When side forms are removed from the curing chamber before the curing cycle (including temperature cooling process) is complete, only the minimum area of the curing chamber enclosure shall be removed and remain uncovered at any one time. The open area in the enclosure shall be immediately closed as each form section is removed. The enclosure shall not remain open for more than 60 minutes.

   When the Contractor elects to remove the beams from the casting bed during the cooling process, appropriate measures shall be taken to keep the beams warm during moving operations, and shall immediately resume the cooling process at the storage area.

7. **Curing:** The Contractor shall provide all approved continuous recording thermometers located in each enclosure and curing chamber. Two recording thermometers shall be provided for each casting chamber having a casting bed length of 100 feet (30 meters) or less. For each additional 100 feet (30 meters) or less in the length of the casting bed, within each chamber,

an additional thermometer shall be provided. The thermometers shall record temperatures at intervals not to exceed 15 minutes and have an accuracy of plus or minus 5° F (3° C).

Complete temperature recording charts for all cures shall be submitted to the Engineer prior to acceptance of the beams. If the records indicate that the specified temperature and time element pertaining to the curing are not being complied with, the affected beams will be subject to rejection.

Curing shall be maintained until the concrete has gained sufficient strength for prestress transfer.

8. **Prestress Transfer:** For pretensioned beams, the prestress transfer shall not be made until the control cylinders, cured with the beams, indicate that the concrete has reached the compressive strength specified in the plans, or as amended by the approved shop drawings.

   Detensioning shall be accomplished after the steam or radiant heat curing has been discontinued and before the concrete temperature drops below 65° F (18° C).

   The prestress transfer sequence shall keep the lateral eccentricity of the prestress to a minimum and shall prevent cracking in the top flange of the beams.

   In addition, the prestress transfer shall be made in accordance with the following:

   When steam or other added heat is used for cure, the prestress transfer shall be made while the concrete in the beams is still warm and moist.

   The prestress transfer may be made by the gradual release of hydraulic jacks, by heating exposed portions of individual strands to failure, or shall be completed as detailed in approved production procedures.

   When heating of individual strands is employed, it shall be subject to the following:

   Heating of each individual strand shall be done simultaneously on the strand at a minimum of two locations along the casting bed. The sequence of heating each strand along the bed, the sequence of prestress transfer between individual strands, and the sequence of release of the hold downs for deflected strands for the prestress transfer shall be such that no deleterious effect will result. A schedule of the proposed prestress transfer operations shall be submitted with the shop drawings.

   Heating shall be done with a large, low oxygen flame along the strand for a minimum distance of five inches (125 mm). The application of heat shall be controlled so that failure of the first wire in the strand does not occur for at least five seconds after heat is applied, followed by gradual elongation and failure of the remaining wires. If the release is not gradual and damages the beam, this method of release shall be discontinued.

9. **Tolerances:** Dimensional tolerances of the completed beams shall not exceed the dimensional tolerances specified in the current edition of Prestressed Concrete Institute Manual for Quality Control for Plants and Production of Precast Prestressed Concrete Products.

10. **Handling, Storage, Transportation, and Installation:** Pretensioned beams may be moved from the casting bed to the storage yard after the prestress transfer strength has been reached but shall not be removed from the casting yard or installed until they have reached the specified minimum design compressive strength, as indicated by the test cylinders cured with the beams.

    Prestressed beams shall remain in an upright position at all times. The beams shall be supported during storage, lifting, and transportation at only two points. During lifting and transporting, each point shall be not farther from the end of the beam than the depth of the beam. During storage, the points shall not be farther from the end of the beam than one third the depth of the beam.

    The prestressed concrete beams shall be installed and fastened in accordance with the details shown in the plans.

560.4 METHOD OF MEASUREMENT

A. Prestressed Concrete Beam: Measurement of prestressed beams will not be made. Plans quantity will be used for payment.

B. Furnishing Precast Box Culvert: Measurement for furnishing precast box culverts will not be made. Plans quantity shall be used for payment.

C. Installing Precast Box Culvert: Measurement for installing precast box culvert will not be made. Plans quantity shall be used for payment

D. Furnishing Precast Box Culvert End Sections: Furnishing precast box culvert end sections will be measured per each. One end section will be considered to be all of the individual pieces required to construct one end of the box culvert.

E. Installing Precast Box Culvert End Sections: Installing precast box culvert end sections will be measured per each. One end section will be considered to be all of the individual pieces required to construct one end of the box culvert.

560.5 BASIS OF PAYMENT

A. Prestressed Concrete Beam: Prestressed concrete beams will be paid at the contract unit price per foot (meter). Payment will be full compensation for furnishing and installing the prestressed concrete beam, and all other incidentals.

B. Furnishing Precast Box Culvert: Furnish precast box culvert will be paid for at the contract unit price per 0.1 foot (0.1 meter). Payment will be full compensation for furnishing the box culvert, joint seal mastic, drainage fabric, and joint ties.

C. Installing Precast Box Culvert: Installing precast box culvert will be paid for at the contract unit price per 0.1 foot (0.1 meter). Payment will be full compensation for precast box culvert installation and will include compensation for foundation preparation, backfilling, and all other incidentals.

D. Furnishing Precast Box Culvert End Sections: Furnishing precast box culverts will be paid for at the contract unit price per each.

E. Installing Precast Box Culvert End Sections: Installing precast box culvert end sections will be paid for at the contract unit price per each.

THIS PAGE INTENTIONALLY LEFT BLANK